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Research Article

Invasive potential of *Phymactis papillosa*: assessing environmental tolerance and ecological impact on the Portuguese intertidal ecosystems

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Abstract

Human activities and environmental changes have significantly increased the introduction of non-native species (NIS) into marine habitats, posing a challenge to biodiversity and ecosystem management. This study presents a comprehensive approach to assess the invasiveness of *Phymactis papillosa*, a recently introduced sea anemone on the Portuguese intertidal coast. An experiment was conducted to evaluate the salinity and temperature tolerances of this species and predict its potential distribution beyond its native range. A total of 270 individuals were used in a two-factor experimental design with groups of six individuals at five temperature treatments (15, 19, 23, 27, 31 °C) and three salinity conditions (32, 35, 38 psu) replicated three times. Mortality levels were measured after two weeks. Results showed that salinity had no impact on mortality, but temperature significantly affected survival. At 31 °C, all individuals died, at 27 °C mortality level was intermediate, and no mortality occurred at 23 °C or lower. These findings suggest that *P. papillosa* could potentially invade the Portuguese coast, the northern Iberian Peninsula, and the North Sea; however the high temperatures of the Mediterranean may be a limiting factor. Being confined to the rocky intertidal zone, *P. papillosa* could compete with native species, particularly with those from the same functional group. Aggressive interactions with six native sea anemone species were induced, with *P. papillosa* dominating three species from the genus *Actinia* and showing equivalent behaviour to *A. sulcata*. This behavioural dominance may negatively impact the spatial distribution of native *Actinia* species. The integration of these findings suggests that *P. papillosa* should be classified as an invasive species with the potential to significantly impact benthic communities along the Portuguese and northern Atlantic intertidal coasts.

Key words: Behaviour, Cnidaria, competition, invasive species, sea anemone

Introduction

Human actions and environmental changes in marine habitats have significantly increased the number of non-native species (NIS), introduced and successfully established outside their native distribution area (Glon et al. 2020). The consequences of these species, particularly in ecological aspects, hold significant relevance for legislators, managers, policymakers, and conservationists when prioritising management actions and allocating funds (Ojaveer et al. 2015). One of the primary anticipated impacts is on natural benthic communities, leading to a reduction in biodiversity and in the growth of other species, potentially caused by competition

(Blackburn et al. 2014; Ojaveer et al. 2015). When these impacts are measurable in ecological and/or socio-economic terms, and there is a capability to spread, the species is termed invasive (Cardeccia et al. 2018).

Biological invasions typically unfold through four fundamental stages (Blackburn et al. 2011): transport, introduction, establishment, and spread. The ecological and biological traits influence the likelihood of successful introduction for certain species within specific taxonomic groups. Cnidarians have several characteristics that are particularly suitable for a successful invasion. These include a diverse range of life history strategies, sexual and asexual reproduction, high dispersal, and tolerance to abiotic factors like temperature and salinity (Shick 1991). Many sea anemone species display a general predisposition towards hardiness and potentially rapid proliferation, making them well-adapted for introduction (Glon et al. 2020). Although asexual reproduction appears to be the most important in invasion success in sea anemones, the ability to reproduce through both asexual and sexual modes in the non-native range, along with the lack of senescence, contributes to a species' ability to be durable invaders (Glon et al. 2020). Worldwide, eleven species of sea anemones have already been described as invasive, with measurable environmental impacts (Glon et al. 2020).

The first invasion stage (transport) is already accomplished when a NIS species is identified. After this initial introduction, factors contributing to the success of the establishment and spread include the ability to acclimate to local environmental conditions, high reproductive rate, and the outcome of ecological interactions with the resident community (Podbielski et al. 2016; Cardeccia et al. 2018; Glon et al. 2020).

In 2020, our research team identified the presence of *Phymactis papillosa* (Lesson, 1830) on the Portuguese rocky intertidal coast (Pereira et al. 2022), a Pacific South American intertidal sea anemone species with no other known records outside its native range (Fig. 1). Three of the four described morphotypes of this species were recorded in Cascais, Portugal, being the red and green the most common ones. Their abundances have been increasing in Portugal (Pereira et al. 2022), but there is no information about the impact or invasiveness of this species. Being intertidal, interspecific competition is expected to occur, mainly due to space resource limitations (Brante et al. 2019) and sea anemones are known to display intra and interspecific aggressive behaviours, which modulate their spatial distribution (e.g., Escribano-Álvarez and López-González 2018).

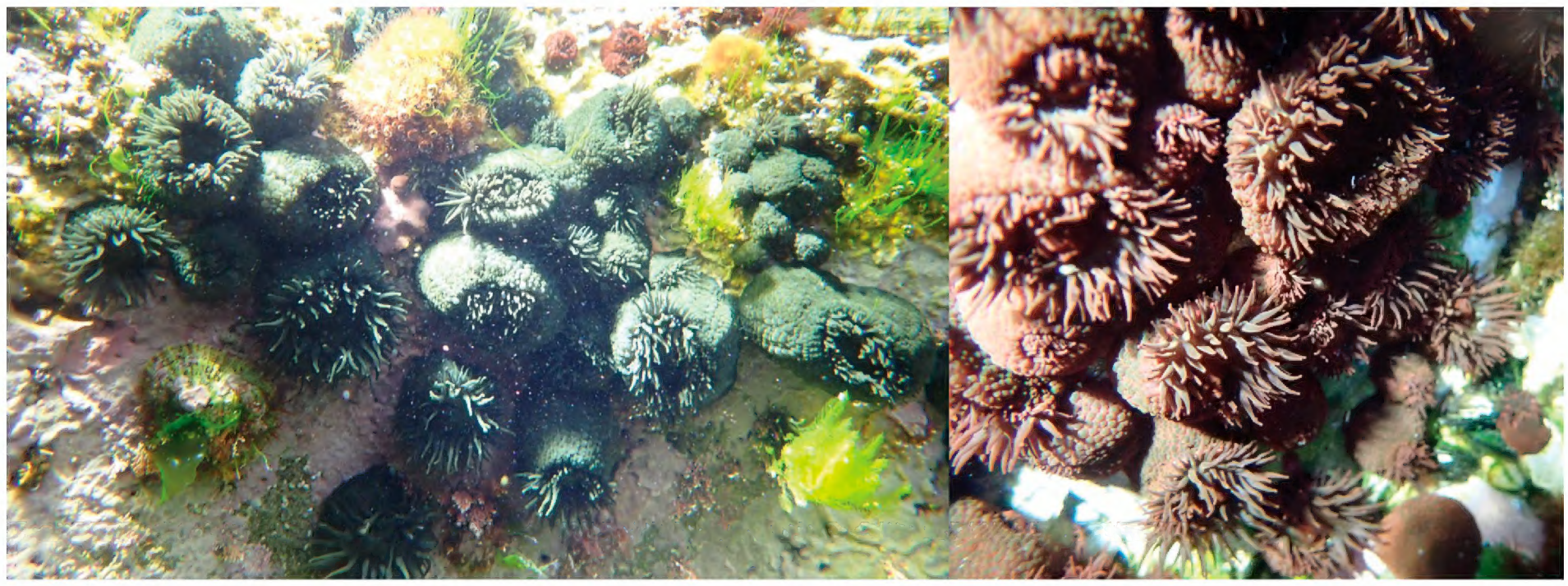

Figure 1. Green and red morphotypes of *Phymactis papillosa.* Photographs taken in June 2025 at Cabo Raso, Cascais, Portugal

In this study, we assessed the invasive potential of *P. papillosa* using two complementary approaches: first, we evaluated its tolerance to abiotic factors to predict its potential distribution along the European coast; second, we examined its behavioural interactions - particularly competition - with native intertidal anemone species to gauge its impact on the ecosystem and clarify its invasive status.

Methods

Temperature and salinity tolerance assessment

A total of 300 individuals of *Phymactis papillosa* were collected in three field trips during the months of October 2023 to January 2024 in Cabo Raso, Cascais, Portugal (38.70954°N, 9.4863°W) where the species is locally abundant. Individuals of various pedal sizes were selected, ranging from 0.6 to 3.5 cm. Half of the individuals belong to the green morphotype and half to the red morphotype. The individuals were randomly selected, carefully removed from the rocky substrate, placed in a container with seawater, and subsequently transported back to the laboratory (i.e. ISPA Bioterium). Prior to any experiment, the organisms were kept for two weeks in a quarantine aquarium at room temperature (approximately 16 °C) and 35 psu salinity, similar to the salinity where they were found.

After acclimation, the anemones were randomly divided into groups of six individuals, half of each morphotype (i.e., red morphotype = 3 individuals; green morphotype = 3 individuals), and placed in fifteen 22 L filtered (with a biological filter with a 10 micra pore size) and aerated aquaria. To evaluate the tolerance of *P. papillosa* to different water temperatures and salinities, a two-factor experimental design was used. Fifteen aquaria were kept at five different temperature treatments (15, 19, 23, 27, 31 °C) and three salinity conditions (32, 35, 38 psu). The salinity and temperature values reflect the variation observed in coastal environments in Portugal, including coastal lagoons (Dias et al. 1999; Newton and Mudge 2003; Sammartino et al. 2022). Animals were placed in fifteen aerated aquaria with 22 L of filtered water without stepwise acclimation, due to challenges in temperature regulation, which required time to stabilize. Temperature and salinity were evaluated and corrected daily, and survival was evaluated daily for a two weeks' period. Fluctuations of up to 1.5 °C were allowed for the selected temperatures. Due to variations in salinity values, the average salinity over the course of the experiment was considered. During acclimation and throughout the experimental procedure, sea anemones were not fed and were maintained under a light/dark cycle that mimicked natural conditions. This experiment was replicated three times with new collected individuals subjected to the same procedure.

Statistical analysis was performed using SPSS Statistics version 29 – IBM Corp. A non-parametric Wilcoxon signed-rank test was used to compare survival rates between sea anemone morphotypes, using the survival rate per aquarium per morphotype as the statistical unit. This test assesses whether significant differences in survival exist between morphotypes, treating them as paired within each aquarium. Non-linear regressions were performed to assess the effects of temperature and salinity on the survival rate of anemones (per aquarium). The most significant models were selected based on higher R square values. Subsequently, the interaction term between variables was added to the model, and its significance was evaluated using an F-change test and the corresponding probability. Finally, survival curve analysis was conducted using the Kaplan-Meier methodology.

Behavioural interactions with the native intertidal anemone species

A total of 120 individuals of *Phymactis papillosa* and approximately 20 individuals of each of six native sea anemone species – *Actinia equina* (Linnaeus, 1758), *Actinia mediterranea* Schmidt, 1971, *Actinia fragacea* Tugwell, 1856, *Anemonia sulcata* (Pennant, 1777), *Actinothoe sphyrodeta* (Gosse, 1858) and *Bunodactis verrucosa* (Pennant, 1777) were collected in several field trips between October 2022 and March 2024 in Cabo Raso, Cascais, Portugal (38.70954°N, 9.4863°W) and Bafureira beach, Cascais, Portugal (38.69206°N, 9.36588°W). Native species were selected based on their local abundance and when multiple morphotypes were present, individuals were randomly chosen. The individuals were randomly selected, carefully removed from the rocky substrate, placed in a container with seawater, and subsequently transported to the laboratory (i.e. ISPA Bioterium), where they were maintained in 20 L to 100 L filtered and aerated aquaria. Each individual species/morphotype was kept in a different aquarium to minimize interspecific aggressive interactions between individuals. Water temperature was 17–18 °C and salinity 35 psu and individuals were fed twice a week with frozen mussels. Prior to any experiment, the sea anemones were left for a month to acclimatize.

After this period, individual tests between *P. papillosa* and each of the native sea anemone species were performed in 5 L aquaria filled with new water at the same salinity and temperature conditions. Each anemone was left for a small period to attach to a small stone. The two stones were then moved together, to allow physical contact between anemones. The interaction between the sea anemones was filmed for one hour, using cell phones cameras. Each individual was only used in one test. The films were sped up 12 times and analysed by two different observers using BORIS (Friard and Gamba 2016). An updated ethogram of sea anemone aggression was made (Table 1 and Fig. 2). The outcome for *P. papillosa* in each contest was categorized as follows: 'win' if *P. papillosa* retained its position and the native sea anemone withdrew, 'lose' if *P. papillosa* withdrew and the native sea anemone retained its position, and 'tie' if both sea anemones either withdrew or remained in their respective positions (after Escribano-Álvarez and López-González 2018). A chi-square test of independence was conducted using SPSS Statistics version 29 (IBM Corp.) to assess the relationship between test outcomes and opponent species.

Table 1. Ethogram of the sea anemone species observed.

Behaviour	Description
Tentacular touch	A sea anemone applies its tentacles to other sea anemone
Column expansion	A sea anemone inflated its column in other sea anemone direction, eventually touching it.
Oral disc application	A sea anemone bends in direction to other, touching it with its oral disc.
Lift opponent	A sea anemone uses its tentacles to lift the opponent and keep it surrounded by its tentacles near its oral disc.
Scapus elevation	A sea anemone elevates the upper part of its column in the opponent's direction.
Acrorhagi use	A sea anemone inflated its *acrorhagi*, bends its body to its opponent and eventually touches it with these structures, which may stay attached to its body.
Tentacle retraction	A sea anemone retracts part or all its tentacles rapidly.
Acontia application	A sea anemone projects *acontia* from its tentacles, mouth or small pores in its collum that adhere to its opponent.
Approach	A sea anemone moves in direction to its opponent, by contraction and distention of its pedal disc.
Withdraw	A sea anemone moves away from its opponent, by contraction and distention of its pedal disc.

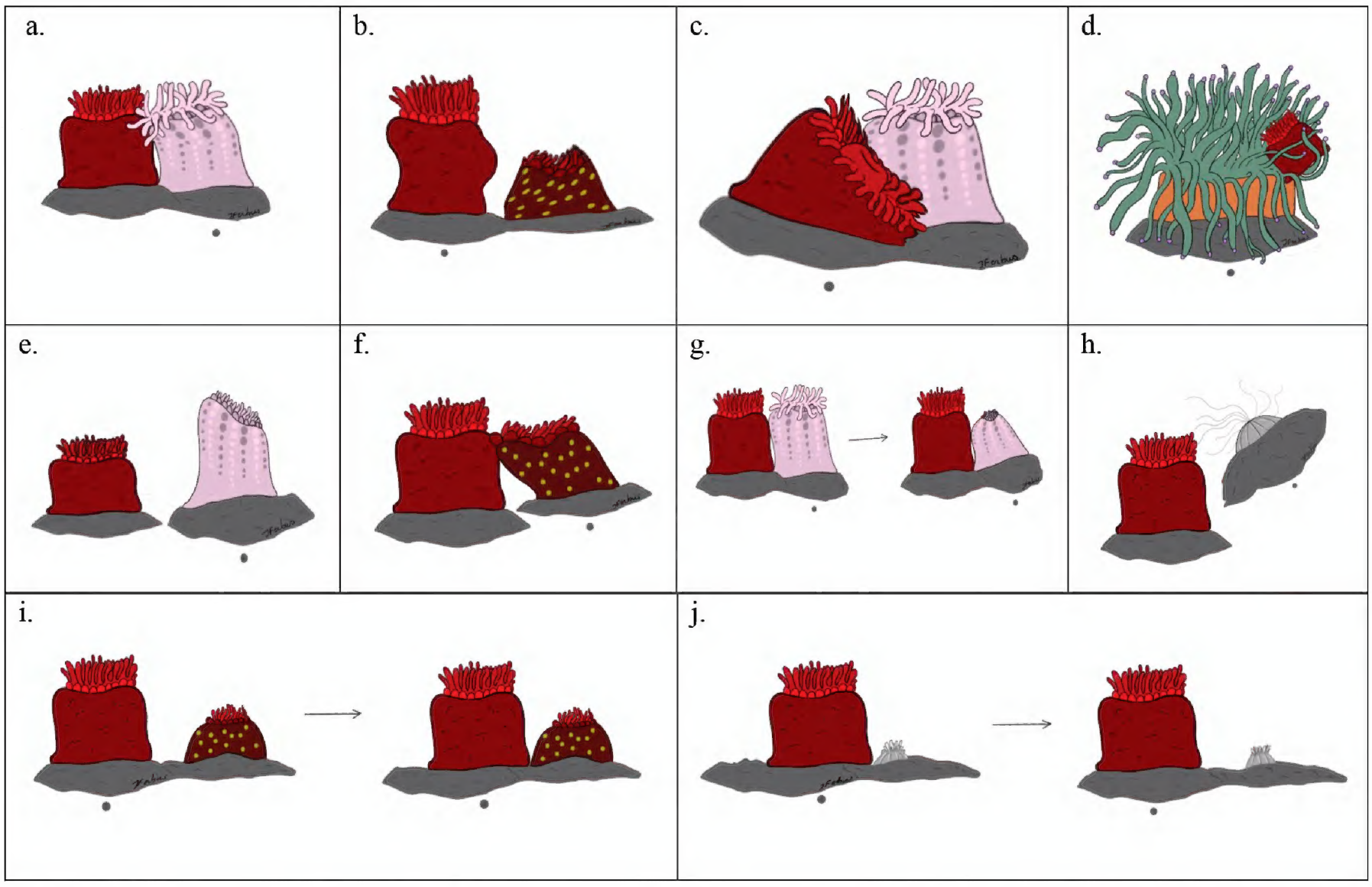

Figure 2. Observed aggressive and defensive behaviours. Descriptions of each behaviour in Table 1. The sea anemone that displayed this behaviour is marked with a point beneath. **a.** Tentacular touch; **b.** Column expansion; **c.** Oral disc application; **d.** Lift opponent; **e.** Scapus elevation; **f.** *Acrorhagi* use; **g.** Tentacle retraction; **h.** *Acontia* application; **i.** Approach; **j.** Withdraw.

Results

Temperature and salinity tolerance assessment

Survival rates by temperature and salinity are presented in Table 2. They were high at temperatures ranging from 15 °C to 23 °C, decreased slightly at 27 °C, and were markedly low at 31 °C (Table 2). No noticeable differences were observed between salinity levels at the same temperatures. Morphotype did not have a significant effect on survival ($T = 11$, $p = 0.291$).

Non-linear regressions indicate that only temperature has a significant impact on *P. papillosa* survival rates (Suppl. material 1). This significant effect remains consistent regardless of the model used; however, the cubic model demonstrated the best fit to the data ($z_{(2,42)} = 142.4$, $p < 0.001$; $r^2 = 0.871$) (Fig. 3). The inclusion of interaction terms between salinity and temperature (temperature^2 and temperature^3) did not significantly improve the explained variance, as it changes from 0.871 to 0.875 ($F\ change_{2;40} = 0.638$, $p = 0.534$).

Kaplan-Meier survival curves illustrate the probability of anemone survival over time (Fig. 4). At 31 °C, anemone survival begins to decrease from the third day onward. By the fourth day the probability of survival is less than 50%, at this temperature. Anemones exposed to temperatures of 15 °C, 19 °C, and 23 °C show a higher probability of survival until the end of the experiment, while those at 27 °C exhibit a survival probability comparable to the lower temperatures, with a slight decrease toward the end of the experiment. The Log-Rank test conducted showed significant differences in survival probabilities among the temperature groups ($X^2 = 345.408$, $p < 0.001$).

Table 2. Survival rate of *P. papillosa* per aquaria by temperature and salinity treatment (N = 3).

Temperature (°C)	Salinity (mean ± standard deviation)	Survival rate (mean ± standard deviation)
15	37.2 ± 0.41	100 ± 0
	34.4 ± 0.37	100 ± 0
	32.0 ± 0.28	88.9 ± 19.2
	Pooled	96.3 ± 11.1
19	37.8 ± 0.53	100 ± 0
	35.2 ± 0.20	94.4 ± 9.6
	31.7 ± 0.68	88.9 ± 19.2
	Pooled	94.4 ± 11.8
23	38.2 ± 0.37	94.4 ± 9.6
	35.5 ± 0.47	94.4 ± 9.6
	32.3 ± 0.29	100 ± 0
	Pooled	96.3 ± 7.3
27	38.7 ± 1.05	72.2 ± 19.2
	35.9 ± 0.19	94.4 ± 9.6
	32.2 ± 0.67	94.4 ± 9.6
	Pooled	87.0 ± 16.2
31	38.7 ± 0.33	0 ± 0
	36.2 ± 1.58	0 ± 0
	33.1 ± 0.77	0 ± 0
	Pooled	0 ± 0

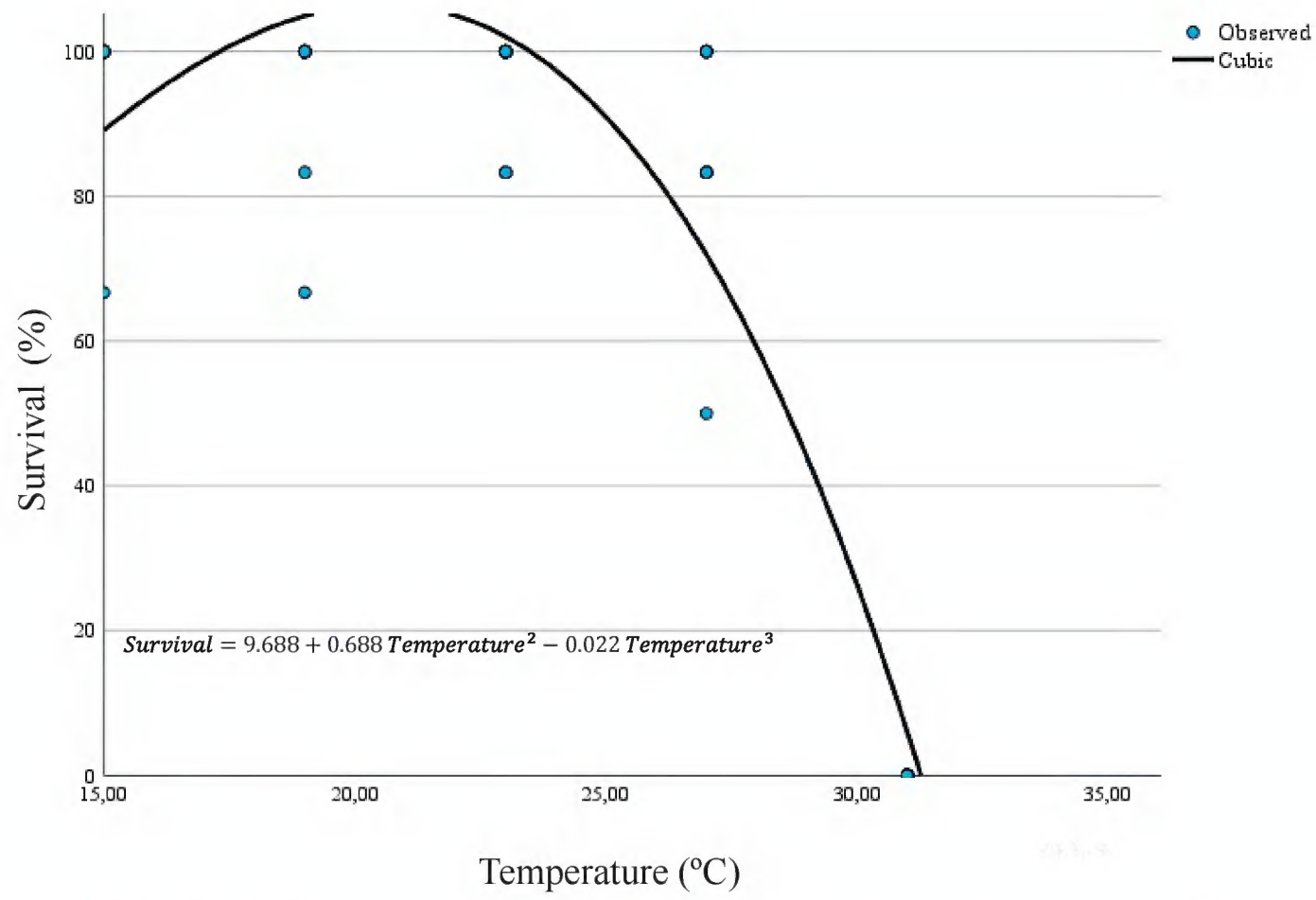

Figure 3. Relationship between percentage survival of *P. papillosa* and temperature exposure following 14 days. A significant cubic model is presented as a black line (*Survival* = 9.688 + 0.688 *Temperature*^{2} – 0.022 *Temperature*^{3}, R^2 = 0.871).

The outcome of all interactions is summarized in Table 3. A chi-square test showed that the outcome is significantly dependent on the opponent species (X^2_{10} = 32.168, $p < 0.001$). The analysis of adjusted standardized residuals shows that *P. papillosa* wins significantly more often against *Actinia equina* and *A. fragacea* and less often with *B. verrucosa*, and loses more often with *Anemonia sulcata* and *A. sphyrodeta* and less often with *Actinia equina*.

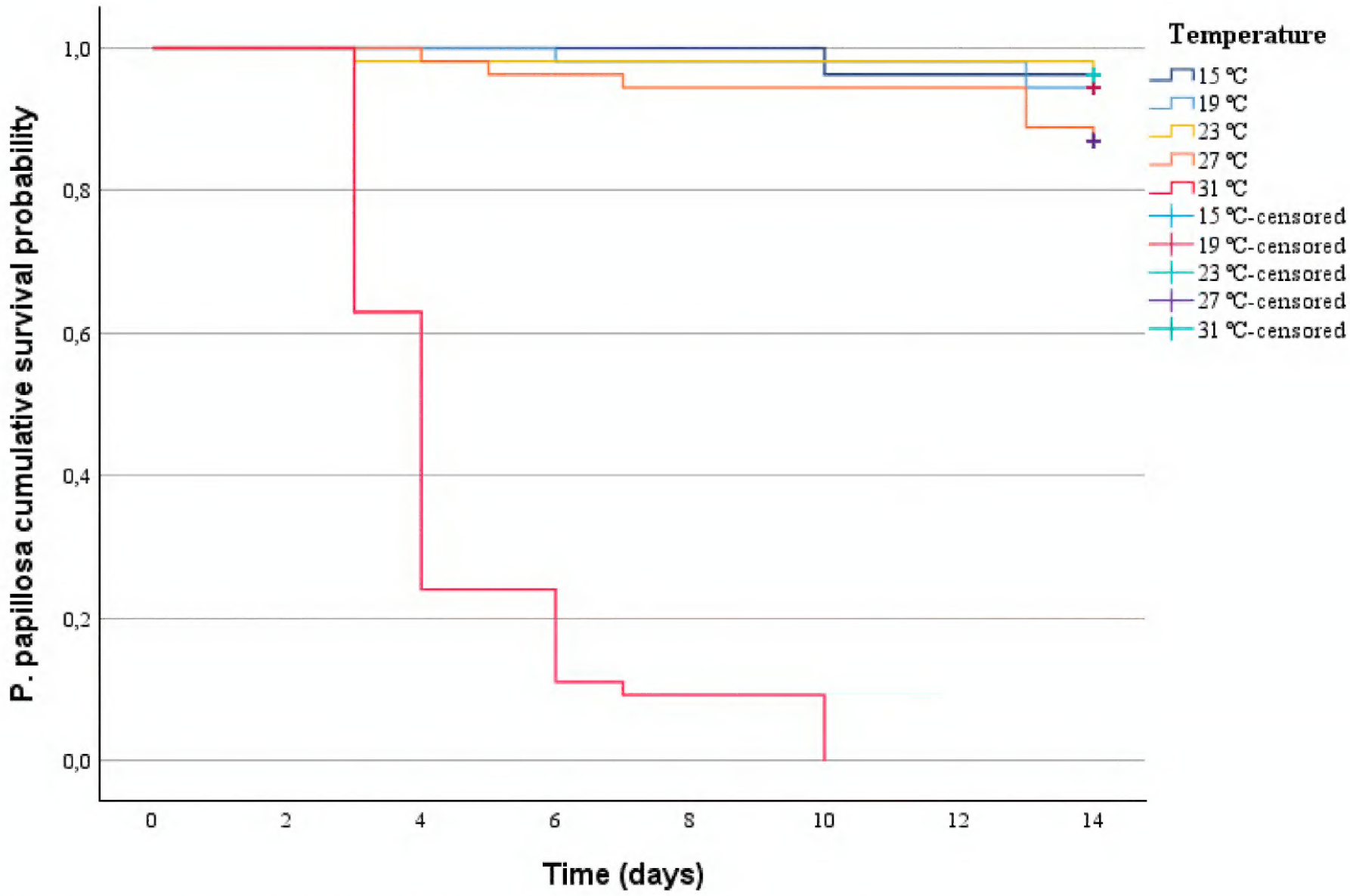

Figure 4. *P. papillosa* Kaplan-Meier survival curves under different temperature treatments.

Table 3. Outcome absolute frequency of 108 contests between *P. papillosa* and six native rocky intertidal sea anemone species. Adjusted standardized chi-square test residuals are presented between square brackets (significant values in bold).

Outcome result for *P. papillosa*	**Opponent species**					
	Actinia equina	***Actinia mediterranea***	***Actinia fragacea***	***Anemonia sulcata***	***Bunodactis verrucosa***	***Actinothoe sphyrodeta***
Win	10 [**2.2**]	6 [0.4]	11 [**3.0**]	3 [-1.5]	1[**-2.6**]	1 [-1.8]
Tie	10 [-0.6]	11 [0.5]	7 [-1.8]	10 [-0.3]	15 [**2.3**]	7 [-0.1]
Loose	0 [**-2.1**]	1 [-1.2]	1 [-1.3]	6 [**2.3**]	3 [0.1]	5 [**2.6**]

Discussion

When a non-indigenous species (NIS) is introduced into a new area, the first stage of invasion, i.e., transport, is already completed. Following this initial introduction, several factors contribute to the species' successful establishment and spread, and so to its invasion success. One of them is its capacity to acclimate to local environmental conditions. Our work showed that temperature has a significant effect on the survival of this species. At temperatures of 15 °C, 19 °C, and 23 °C, the specimens of *P. papillosa* studied survived, while at 27 °C, there was a slight decrease in survival levels. Only at 31 °C was there evidence of compromised survival for this species, particularly after three days of exposure to this temperature. This result suggests that the maximum tolerance limit for this species is 31 °C or less. In fact, according to the non-linear regression equation estimated, at 29 °C only 52% of the anemones survive. These results suggest a high potential for this species to colonize the Portuguese and northern Iberian coast. In its native habitat, this

species is exposed to a range of temperatures consistent with the results obtained (see Haussermann 2004).The similarity between temperatures in the native range of *P. papillosa* and those along the Portuguese coast likely facilitates its successful establishment and potential invasion. However, the colonization of the Mediterranean, where water temperatures experience significant fluctuations between winter and summer (Simolo et al. 2014), is highly compromised during the summer months. While this species can tolerate lower winter temperatures, the rise in summer temperatures would lead to very low survival rates, severely hindering the establishment of the species in this area. Regarding the salinity study, we found no significant effect on the survival of *P. papillosa*, indicating that this species is tolerant to the range of salinities studied (32–38 psu). Therefore, we can conclude that this species is capable of colonizing both oceanic environments and estuarine areas.

Despite providing insights into the salinity and temperature tolerance of *P. papillosa*, the experimental design used in this study presents several limitations. In natural intertidal environments, individuals of this species are regularly exposed to rapid and often unpredictable fluctuations in both temperature and salinity due to tidal cycles, solar radiation, evaporation, and freshwater inputs. These dynamic conditions were not replicated in our experiment, where more stable and controlled parameters were applied. Additionally, the experimental animals were not fed throughout the trial. We adopted this approach to avoid confounding variability in food intake among individuals of different sizes, but it can influence survival outcomes, particularly at higher temperatures where metabolic rates are expected to be elevated (Seebacher et al. 2014). The combination of energetic stress from increased metabolic demands and the absence of nutritional input could have exaggerated mortality or physiological stress. Given these limitations, the results of this study should be interpreted as indicative rather than conclusive.

These results, associated with the high reproductive rate already observed in this species in Portugal (Pereira et al. 2022), indicate that it can successfully establish and spread along the Portuguese coast. In this context, *P. papillosa* is expected to compete for space, particularly with organisms belonging to the same functional groups that share similar needs, such as various species of anemones and corals (Escribano-Álvarez and López-González 2018). Establishing spatial dominance in these species within a habitat where attachment space is limited increases the likelihood of better developing other essential biological functions, such as growth, feeding, or reproduction.

In sea anemones, competition for space is closely tied to competition for food, as these organisms are slow-moving, remain attached to the substrate, and rely on passive mechanisms for feeding. In sedentary species that feed by filtration, interspecific competition is often reported in the intertidal zone for food and space resources (Brante et al. 2019). In the Portuguese intertidal rocky coast, several species of sea anemone occur, with some of the most widespread being those of the genus *Actinia* some of the most widespread (Pereira et al. 2014, 2021). Our results show that *P. papillosa* is particularly dominant regarding *Actinia equina* and *Actinia fragacea*, two of the most frequent sea anemone species in the Portuguese intertidal. These two species, as *P. papillosa*, possess *acrorhagi*, specific structures used in inter and intraspecific agonistic interactions. No noticeable differences are observed when the *cnidae* cell types are compared (described by Haussermann 2004 and Watts et al. 2000). Anyway, when in contact with two these native species, *P. papillosa* only withdraws in 2.5% of the tests performed, and globally only in less than 15% of the tests. This means that in 85% of the tests, *P. papillosa* can

adversely impact native species, either by causing their displacement or by competing directly for resources within the same area. Based on these findings, *P. papillosa* may be classified as an invasive species in Portugal, as it fulfils the criteria commonly used to define biological invasiveness: it is a non-native species capable of establishing and reproducing beyond its natural range (Pereira et al. 2022), and it exerts ecological impacts, particularly on native sea anemone populations.

In conclusion, *P. papillosa* shows a wide temperature and salinity tolerances, aggressive dominance over native sea anemones, and strong invasive potential across the Portuguese and northern Atlantic intertidal coasts. These findings underscore the urgent need for monitoring and management to safeguard benthic communities and maintain coastal biodiversity.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

Conceptualization: JIR, AMP. Formal analysis: AMP, TT, NT. Investigation: JF, AMP, NT, TT. Supervision: JIR, AMP. Writing – original draft: TT, NT, AMP. Writing – review and editing: TT, JF, AMP, JIR, NT.

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

References

Blackburn TM, Pyšek P, Bacher S, Carlton JT, Duncan RP, Jarošík V, Wilson JRU, Richardson DM (2011) A proposed unified framework for biological invasions. Trends in Ecology & Evolution 26(7): 333–339. https://doi.org/10.1016/j.tree.2011.03.023

Blackburn TM, Essl F, Evans T, Hulme PE, Jeschke JM, Kühn I, Kumschick S, Marková Z, Mrugała A, Nentwig W, Pergl J, Pyšek P, Rabitsch W, Ricciardi A, Richardson DM, Sendek A, Vilà M, Wilson JRU, Winter M, Genovesi P, Bacher S (2014) A unified classification of alien species based

on the magnitude of their environmental impacts. PLoS Biology 12(5): e1001850. https://doi.org/10.1371/journal.pbio.1001850

Brante A, Riera R, Riquelme P (2019) Aggressive interactions between the invasive anemone *Anemonia alicemartinae* and the native anemone *Phymactis papillosa.* Aquatic Biology 28: 127–136. https://doi.org/10.3354/ab00718

Cardeccia A, Marchini A, Occhipinti-Ambrogi A, Galil B, Gollasch S, Minchin D, Narščius A, Olenin S, Ojaveer H (2018) Assessing biological invasions in European Seas: Biological traits of the most widespread non-indigenous species. Estuarine, Coastal and Shelf Science 201: 17–28. https://doi.org/10.1016/j.ecss.2016.02.014

Dias JM, Lopes J, Dekeyser I (1999) Hydrological characterisation of Ria de Aveiro, Portugal, in early summer. Oceanologica Acta 22(5): 473–485. https://doi.org/10.1016/S0399-1784(00)87681-1

Escribano-Álvarez P, López-González PJ (2018) Facing the arrival of newcomers: An intertidal sea anemone approach (Hexacorallia, Actiniaria). Biological Invasions 20(10): 2945–2962. https://doi.org/10.1007/s10530-018-1748-6

Friard O, Gamba M (2016) BORIS: A free, versatile open-source event-logging software for video/audio coding and live observations. Methods in Ecology and Evolution 7(11): 1325–1330. https://doi.org/10.1111/2041-210X.12584

Glon H, Daly M, Carlton JT, Flenniken MM, Currimjee Z (2020) Mediators of invasions in the sea: Life history strategies and dispersal vectors facilitating global sea anemone introductions. Biological Invasions 22(11): 3195–3222. https://doi.org/10.1007/s10530-020-02321-6

Haussermann V (2004) Re-description of *Phymactis papillosa* (Lesson, 1830) and *Phymanthea pluvia* (Drayton in Dana, 1846) (Cnidaria: Anthozoa), two common actiniid sea anemones from the southeast Pacific with a discussion of related genera. Zoologische Mededelingen 78(18–28): 345–381.

Newton A, Mudge SM (2003) Temperature and salinity regimes in a shallow, mesotidal lagoon, the Ria Formosa, Portugal. Estuarine, Coastal and Shelf Science 57(1–2): 73–85. https://doi.org/10.1016/S0272-7714(02)00332-3

Ojaveer H, Galil BS, Campbell ML, Carlton JT, Canning-Clode J, Cook EJ, Hewitt CL, Jelmert A, Marchini A, McKenzie CH, Minchin D, Occhipinti-Ambrogi A, Olenin S, Ruiz G (2015) Classification of non-indigenous species based on their impacts: Considerations for application in marine management. PLoS Biology 13(4): e1002130. https://doi.org/10.1371/journal.pbio.1002130

Pereira AM, Brito C, Sanches J, Sousa-Santos C, Robalo JI (2014) Absence of consistent genetic differentiation among several morphs of Actinia (Actiniaria: Actiniidae) occurring in the Portuguese coast. Zootaxa 3893(4): 595–600. https://doi.org/10.11646/ZOOTAXA.3893.4.9

Pereira AM, Cadeireiro E, Ocaña O, Vukić J, Šanda R, Mirimin L, Robalo JI (2021) Molecular and morphological validation of the species of the genus *Actinia* (Actiniaria: Actiniidae) along the Atlantic Iberian Peninsula. Regional Studies in Marine Science 42: 101648. https://doi.org/10.1016/J.RSMA.2021.101648

Pereira AM, Silva MM, Mateus O (2022) First record of *Phymactis papillosa* (Lesson, 1830), a Pacific south sea anemone in European shores. Journal of the Marine Biological Association of the United Kingdom 102(5): 350–353. https://doi.org/10.1017/S0025315422000571

Podbielski I, Bock C, Lenz M, Melzner F (2016) Using the critical salinity (S crit) concept to predict invasion potential of the anemone *Diadumene lineata* in the Baltic Sea. Marine Biology 163: 1–15. https://doi.org/10.1007/s00227-016-2989-5

Sammartino M, Aronica S, Santoleri R, Buongiorno Nardelli B (2022) Retrieving Mediterranean Sea surface salinity distribution and interannual trends from multi-sensor satellite and in situ data. Remote Sensing 14(10): 2502. https://doi.org/10.3390/rs14102502

Seebacher F, White CR, Franklin CE (2014) Physiological plasticity increases resilience of ectothermic animals to climate change. Nature Climate Change 5: 51–56. https://doi.org/10.1038/nclimate2457

Shick JM [Ed.] (1991) A functional biology of sea anemones. Springer Science & Business Media, 1–395. https://doi.org/10.1007/978-94-011-3080-6_1

Simolo C, Brunetti M, Maugeri M, Nanni T (2014) Increasingly warm summers in the Euro-Mediterranean zone: Mean temperatures and extremes. Regional Environmental Change 14: 1825–1832. https://doi.org/10.1007/s10113-012-0373-7

Watts PC, Allcock AL, Lynch SM, Thorpe JP (2000) An analysis of the nematocysts of the beadlet anemone *Actinia equina* and the green sea anemone *Actinia prasina.* Journal of the Biological Association of the United Kingdom 80: 719–724. https://doi.org/10.1017/S002531540000254X

Supplementary material 1

Supplementary table

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Data type: docx

Explanation note: Summary of regression model results testing the relationship between survival rate and two independent variables – temperature and salinity. – using different models (linear, logarithmic, inverse, quadratic, and cubic). For each model, the F statistic, associated p-value, and coefficient of determination (R2) are reported. Significant models ($p < 0.05$) are observed only for temperature, with the highest explanatory power achieved by the cubic model.

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